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ARTHRODESIS FOR FAILED KNEE ARTHROPLASTY

A Report of 20 Cases

by

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Twenty consecutive patients treated by arthrodesis for failed knee arthroplasty are reviewed. Eight hinged, five stabilised and seven compartmental prostheses were removed, for infection (15 cases), loosening (4) and instability (1). One patient refused a second-stage operation but the remainder gained sound fusion.

Infected knees had a two-stage procedure with temporary insertion of gentamicin-loaded beads after removal of the prosthesis; all infections healed. Six arthrodeses using a Hoffmann-Vidal external fixator resulted in two temporary failures. One Ace-Fischer external fixation was successful. Of 10 primary attempts at arthrodesis with an intramedullary Küntscher nail, nine were successful; the tenth fused after two more attempts by the same method. The two failures of external fixation and two failures after Charnley single-frame compression done elsewhere were successfully fused with intramedullary nails. Delayed union in three cases fused after prolonged fixation and repeated bone grafts.

The indications for and methods of arthrodesis after failed knee arthroplasty are discussed.

Tew and Waugh (1982) estimated the results of knee arthroplasties in terms of survival rate, and found the cumulative risk of failure to reach one quarter within five years. Reports on the unicondylar (Insall and Aglietti 1980), UCI (Hamilton 1982) and Marmor endoprostheses (Marmor 1982) with follow-up of over five years support this finding. The best five-year result so far reported has only seven revised failures from 100 total knee replacements (Insall *et al.* 1983). Some of the failures in these series were not suitable for revision arthroplasty and were treated by arthrodesis.

Sound fusion in these secondary arthrodeses is usually said to be difficult to achieve, and few reports are available (Deburge *et al.* 1976; Hagemann, Woods and Tullos 1978; Brodersen *et al.* 1979; Vahvanen 1979; Cameron and Hunter 1982; Woods, Lionberger and Tullos 1983). Since failure of fusion of an arthrodesis usually results in considerable disability (Knutson *et al.* 1984b), it is important to develop methods that can improve the fusion rate. Bigliani *et al.* (1983) reported that the main reasons for failure in 18 secondary arthrodeses were inability to control infection, loss of metaphyseal bone and inadequate stabilisation. This report describes 20 cases of attempted arthrodesis.

MATERIAL AND METHODS

Over a six-year period from 1977 to 1982 arthrodesis of the knee was attempted for 20 consecutive patients after failure of knee arthroplasty. Seventeen of these were done under the supervision of one of the authors (LL) at the Department of Orthopaedics, University Hospital in Lund, and three were done elsewhere after consultation. Eleven of the 17 patients had been referred from other hospitals. There were 13 women and seven men with an average age of 66 years (range 47 to 82 years). The indications for the primary arthroplasty had been rheumatoid arthritis in 11 patients, osteoarthritis in five and fracture of the knee with secondary arthritis in four. Eight of the primary arthroplasties had previously been revised, by exchange of the prosthesis in seven and by the addition of components in one single-compartment arthroplasty.

The prosthesis which was removed at the time of arthrodesis was of the hinge type in eight (5 Guepar, 2 St Georg, 1 Shiers); of the stabilised type in five (4 Attenborough, 1 Sphero-centric) and of the one, two or three-compartment types in the remaining seven (1 total condylar, 1 Richards maximal contact, 1 Geomedic, 3 Marmor modular, 1 St Georg-Sledge) (Table I). The complication for which arthrodesis was required was deep infection in 15 cases, mechanical loosening in four and severe instability in one. Thirteen patients had had one or more knee operations as well as their final knee arthroplasty before arthrodesis.

In this study infection was considered to be proven when one or more of the following four criteria were present: a fistula from the joint or adjacent bone; three or more positive cultures from five tissue biopsies taken at

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Table 1. Details of 20 patients undergoing operations for failed knee arthroplasty

Case	Age (years)	Sex	Diagnosis*	Previous operations Type of prosthesis	Cause of failure	Operations for arthrodesis†	Follow-up		
							Period (months)	Shortening (cm)	Result
1	80	F	OA	Tibial osteotomy <i>Guepar</i>	Deep infection	1. Beads and H-V fixation	53	9	Fused, painfree
2	66	M	RA	Lateral <i>Marmor</i> Medial <i>Marmor</i>	Loosening and low-grade infection	1. IM nail and bone graft	29	3	Fused, painfree Died of unrelated disease
3	80	F	OA	Tibial osteotomy <i>St Georg</i> (fractured) <i>St Georg</i>	Deep infection	1. H-V fixation 2. IM nail 3. Reinsertion of nail	19	8	Fused Late supracondylar fracture healed Painfree
4	54	F	RA	<i>Guepar</i>	Deep infection	1. Beads and H-V fixation 2. Sinus excision 3. IM nail	18	5	Fused, painfree
5	76	F	OA	<i>Total condylar</i>	Deep infection and septicaemia	1. Beads 2. IM nail	12	3	Fused, painfree
6	55	M	Sec OA	<i>Attenborough</i> (infected) <i>Attenborough</i>	Deep infection	1. Beads 2. IM nail and bone graft 3. Bone graft	28	5	Fused, slight pain Uses one stick
7	53	M	Sec OA	<i>Guepar</i> Multiple revisions	Deep infection	1. Beads 2. IM nail and cerclage for fracture	12	4	Fused, fracture healed Painfree
8	60	M	Sec OA	<i>Spherocentric</i>	Wound breakdown Deep infection	1. Beads and H-V fixation 2. Bone graft	6	3	Fused, painfree
9	55	M	RA	<i>Guepar</i> (loose) Revision <i>Shiers</i> Revision	Progressive bone resorption and loosening	1. Beads 2. IM nail and bone graft 3. Change IM nail; bone graft 4. Change IM nail; bone graft	6	8	Fused, painfree Uses crutches
10	47	M	RA	Synovectomy <i>Marmor</i> (loose) <i>Attenborough</i>	Instability and loosening	1. H-V fixation	6	1	Fused, painfree
11	72	F	Sec OA	Tibial osteotomy <i>Geomedic</i>	Loosening	1. Charnley clamps 2. IM nail	4	4	Fused Died from unrelated disease
12	71	F	RA	<i>St Georg-Sledge</i> Fixation of supracondylar fracture	Deep infection and pseudarthrosis	1. IM nail	12	2	Fused, painfree Walking frame
13	73	F	RA	<i>Guepar</i> (loose) <i>Guepar</i>	Deep infection and loosening	1. Beads 2. Revision and beads 3. A-F fixation and bone graft 4. Bone graft	11	4	Fused, proximal fracture healed in brace Painfree Uses crutches
14	69	F	OA	<i>Marmor</i>	Instability, loosening, grossly overweight	1. IM nail	6	2	Fused, painfree
15	73	F	RA	<i>Marmor</i> <i>Richards maximal contact</i>	Skin necrosis and deep infection	1. Charnley clamp 2. Revision and beads 3. Revision and beads 4. IM nail and bone graft	7	5	Fused, painfree
16	56	F	RA	Synovectomy <i>Attenborough</i> (loose) <i>Attenborough</i>	Deep infection and septicaemia	1. Beads 2. IM nail and bone graft	9	4	Fused Supracondylar fracture healed Painfree
17	61	F	RA	<i>Attenborough</i>	Deep infection	1. Beads 2. Revision and beads 3. IM nail and bone graft	11	2	Fused, painfree Uses sticks
18	57	F	RA	<i>Marmor</i>	Instability	1. H-V fixation	6	1	Fused, painfree
19	70	M	OA	<i>St Georg</i> Osteosynthesis of femoral fracture	Deep infection and bone resorption	1. Beads 2. IM nail and bone graft	8	4	Stable fibrous union
20	82	F	RA	<i>Guepar</i>	Deep infection	1. Beads (Brace)	4	4	Cardiac infarction after removal of prosthesis Refused arthrodesis

*Diagnosis: OA, osteoarthritis; RA, rheumatoid arthritis; Sec OA, osteoarthritis secondary to fracture

†Beads, insertion of beads containing gentamicin; H-V, Hoffmann-Vidal external fixation; A-F, Ace-Fischer external fixation; IM, intramedullary nailing

operation (Kamme and Lindberg 1981); septicaemia with isolation of the same bacteria in the blood and the knee aspirate; or growth of the same bacteria in two or more knee aspirations.

Certain principles of treatment were followed. For proven infection a two-stage procedure was normally used. At the *first stage* the prosthesis and all bone cement and infected debris were removed, cutting anterior slots in the femur and tibia when necessary. The least possible amount of the bone ends was resected to improve the contact area of the arthrodesis. The posterior capsular attachment and the head of the fibula were resected if more bone contact was required. The cavities in the femur and the tibia and the space between the bone ends were then filled with cement beads containing gentamicin (Septopal). Any fistulae were excised and the skin closed, using local plastic procedures if necessary.

If external fixation (most often with the Hoffmann-Vidal fixator) was to be used, it was applied during the first stage. If internal fixation was planned, the knee was supported with a dorsal plaster slab so that the patient could, within a few days, be up on crutches while awaiting the second operation. In infected cases systemic antibiotic treatment was often started before revision. If this had not been done, treatment was started after five cultures had been taken during operation. In cases of proven infection, antibiotic treatment was continued until the knee was fused. Any skin problems remaining after the first stage were dealt with before the actual fusion operation.

The *second stage* of treatment for the infected cases was performed when the infection had settled and the wound was well healed, usually four to six weeks after the first stage. At the second stage the gentamicin-containing beads were removed, the proximal tibia and distal femur were decorticated and a large amount of cancellous bone was transferred from the iliac crest to the knee. The condyles were sometimes chiselled off to obtain a better shape and bone contact; bone so obtained was also used as graft. The external fixation device was retained during the second stage unless internal fixation was planned. For internal fixation a long intramedullary Küntscher nail was inserted from the greater trochanter of the femur to below the narrowest part of the medullary canal of the tibia after reaming both bones (Fischer 1983; Knutson and Lidgren 1982). A dorsal brace was used after operation to provide additional rotatory stability. The patient was allowed up on crutches after a few days and full weight-bearing started after six weeks.

Twelve of the 15 patients with deep infection were treated by a two-stage procedure (Table II). In Case 2 infection was not diagnosed before arthrodesis, and in Case 12, where there was an infected pseudarthrosis in the supracondylar region, the knee was stabilised during the first-stage operation to provide better control of infection.

Mechanical failures of knee arthroplasty in the absence of infection were treated by a one-stage procedure at which the prosthesis was removed and either external or internal fixation combined with bone grafting was used. Of the five knees fused for mechanical failure, two (Cases 14 and 18) had Marmor arthroplasties with instability; one of these was also loose and the patient was extremely overweight. One patient with a loose Geomedic prosthesis (Case 11) was referred to us for a second attempt at fusion after failure of a Charnley-type compression arthrodesis. The other two uninfected knees (Cases 9 and 10) were arthrodesed because of loosening in both primary and in secondary replacement arthroplasties. One of these patients had osteolytic bone destruction of the type usually seen in low-grade infection and was therefore treated in two stages; repeated bacteriological tissue cultures were, however, negative (see case report on page 50).

Table II. Revision procedures used in 20 patients with failure of knee arthroplasty

Type of failure	One-stage procedure	Two-stage procedure	Total
Deep infection	3	11 + 1*	15
Mechanical loosening	3	1	4
Severe instability	1	—	1

*In one patient the planned second-stage operation was refused

Follow-up continued at least until the knee was soundly fused, on average for 13 months (range 4 to 53 months). External fixators were regularly checked and compression adjusted. Radiographs were taken soon after operation and at four months, at which time clinical stability was usually tested; radiographic follow-up averaged 11 months (range 3 to 41 months). If fusion was not sound at four months a secondary bone graft was considered and the fixation was continued. If fusion was clinically sound at this time, the external fixator was replaced by a brace for one to two months to protect the union and encourage further bone healing. Knees which had been fixed by intramedullary nails were tested for rotatory stability and the brace was removed when this had been achieved.

RESULTS

Method of fixation. The treatment and results for each patient are summarised in Table I. The first attempt at arthrodesis in nine of the patients was with external fixation (Table III). In six of these nine a Hoffmann-Vidal quadrilateral fixator with six transverse Steinmann pins was used (Connes 1977). Three of these six patients (Cases 1, 3 and 4) were undergoing revision of long-stemmed hinge prostheses; two of the three failed to fuse but later had successful operations with intramedullary nail fixation. Two were revisions of short-stemmed stabilised prostheses (Cases 8 and 10) and both

Table III. Attempted method of arthrodesis related to type of knee arthroplasty

Attempted method of arthrodesis	Type of arthroplasty			
	Hinge	Stabilised	Two and three compartment	Single compartment
Hoffmann-Vidal external fixator	3 (2 failed)	2	—	1
Ace-Fischer external fixator	1	—	—	—
Intramedullary nail, primary attempt	3 (1 failed)	3	1	3
Intramedullary nail, after failure of primary method	4 (1 failed)	—	*2	—

* Initially treated elsewhere by Charnley single-frame fixation

fused with external fixation, though one needed further bone grafts. One patient (Case 18) had a unicompartmental prosthesis removed and fused uneventfully.

Two patients (Cases 11 and 15) with two and three compartment prostheses had been initially treated elsewhere by Charnley single-frame fixation and had failed to fuse. Arthrodesis was successful with intramedullary nail fixation. One patient (Case 13) with large bony defects and a long-stemmed hinge prosthesis gained sound fusion after further grafts and immobilisation in an Ace-Fischer fixator with the additional support of ventral pins (Knutson, Bodelind and Lidgren 1984a).

Table IV. Shortening of the leg after arthrodesis for failed knee arthroplasty

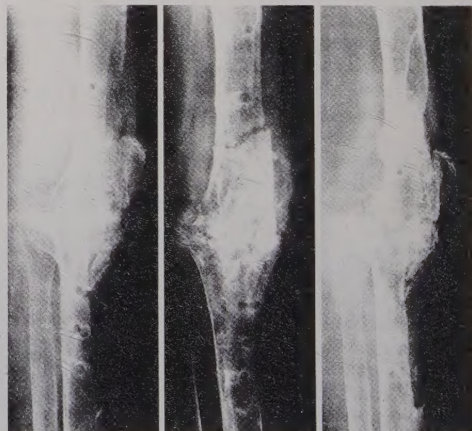
Shortening (cm)	Type of arthroplasty			
	Hinge	Stabilised	Two and three compartment	Single compartment
0-2	—	2	—	3
3-4	4	2	2	1
5-6	1	1	1	—
7-8	2	—	—	—
>8	1	—	—	—

In 10 patients an intramedullary nail was used at the primary fusion operation; in four patients an intramedullary nail was used at the second attempt at fusion. All knees in which intramedullary nail fixation was used eventually fused, though one patient after primary treatment with an intramedullary nail needed two more operations for nail fixation and bone grafting (Case 9, case report). All healed fusions but one (Case 19) showed bridging callus; in the one exception the knee was clinically stable with fibrous union, but the patient had slight pain in the hip on weight-bearing. The average clinical shortening of the legs after fusion was 4 cm (Table IV).

Complications. The removal of the prosthesis resulted in small fissure fractures of the condyles in some patients, but these had no adverse effects on healing or fusion. Two patients (Cases 3 and 16) sustained more major supracondylar and condylar femoral fractures, but in each case the arthrodesis and the fracture healed uneventfully after intramedullary nail fixation. A lateral flake fracture of the proximal femur occurred during insertion of the intramedullary nail in one patient (Case 19) and another patient (Case 7) sustained a subtrochanteric fissure fracture, which needed fixation by two Partridge nylon cerclage bands (Partridge 1976). Both fractures healed.

One patient (Case 13) sustained a femoral fracture through the proximal pin holes after removal of an external fixator which had helped to produce fusion of the knee; this fracture healed in a brace (Figs 1, 2 and 3). In two cases (Cases 3 and 9) the intramedullary nail migrated proximally and needed reinsertion (see case report, Figs 4 to 7). Fistulae required revision in five patients (Cases 1, 4, 13, 15 and 17) before arthrodesis; in Case 15 closure was by a myocutaneous flap from the medial gastrocnemius. There were no septic reactions to the operations and no further flaring up of infection after arthrodesis. One patient (Case 20) had a cardiac infarction after removal of the prosthesis and later refused operation for arthrodesis; at the latest review the knee was ununited and was supported by a brace.

Case 9. A 49-year-old man with rheumatoid arthritis had a Guepar knee replacement. A fistula persisted for three months postoperatively, but this healed after revision. The knee functioned well for three years, but bone resorption and subsidence of the prosthesis then developed. The Guepar prosthesis was replaced with a Shiers prosthesis; gentamicin-loaded bone cement was used. Multiple cultures of tissue



Case 13. Figure 1—Lateral radiograph of the fused knee after removal of an Ace-Fischer external fixator. Note the anterior bone defects after a revision arthroplasty. Figure 2—Oblique radiograph showing a stress fracture of the femur which occurred two days later through a pin hole. Figure 3—Lateral radiograph of the healed fracture.

biopsies were negative, and a fistula which appeared after operation was successfully excised. Knee function was good for four years but then resorption and subsidence reappeared. The prosthesis and a large amount of granulation tissue was removed and the cavity was filled with gentamicin-containing beads (Septopal). There were large bone defects but no pus and again multiple cultures were negative.

One month later arthrodesis was performed using a 64 cm Küntscher nail, 14 mm in diameter. A large amount of cancellous bone from the iliac crest was grafted into the cavity. A dorsal brace was used after operation, but resorption around the nail allowed proximal migration. After 18 months the nail broke at the original knee level (Fig. 4) and was replaced with a wider, 16 mm, nail. More cancellous bone was grafted. The larger nail also migrated proximally (Fig. 5) and was reinserted, but four months later further movement necessitated replacement with a locking-nail (Klemm 1978) which was fixed with a screw through the trochanter (Fig. 6). More cancellous bone was grafted. Six months later the knee was stable and painfree, while bridging callus was visible on radiographs (Fig. 7).

DISCUSSION

A recent review of the literature by Stulberg (1982) reported a fusion rate of between 25% and 100% when external fixation was used in arthrodesis for failed knee arthroplasty. The higher fusion rates were seen in arthrodeses after unconstrained arthroplasties. The main reasons for failure of secondary arthrodesis are: inability to control infection (Bigliani *et al.* 1983), poor bone stock (Brodersen *et al.* 1979) and unstable fixation (Hagemann *et al.* 1978; Vahvanen 1979). Large defects in the metaphyseal bone are most often seen in failed hinge arthroplasties (Hankin, Louie and Matthews 1981). In primary arthrodesis and in arthrodesis for the failure of a unicompartmental replacement, the bone stock is usually good and the fusion rate is high, even with the use of the Charnley single-frame compression and plaster fixation (Charnley 1948; Skolnick *et al.* 1976).

In cases with good bone stock the authors prefer to use the Hoffmann-Vidal quadrilateral fixator (Connes 1977). This does not require further stabilisation with

plaster and therefore gives better access to the wound and to the skin. Where the bone stock is poor this fixator needs improved stability, especially in the antero-posterior plane. This has been demonstrated in a biomechanical study by Knutson *et al.* (1984a). In the present series three arthrodeses were attempted with the Hoffmann-Vidal fixator after hinge arthroplasty and two of them failed (Table III). We therefore advise the use of additional ventral frames with sagittal pins or the Ace-Fischer fixator (Brooker and Hansen 1981; Fidler 1983; Fischer 1983).

The technique and the problems of intramedullary nail fixation for knee arthrodesis have previously been discussed by the authors (Knutson and Lidgren 1982). The indications for nailing include: poor bone stock, fractures, overweight patients, relative weakness of legs or arms, and patients who refuse to have external fixation. The insertion of a long intramedullary nail is a major surgical procedure and the nail itself may migrate or fracture. If the nail needs replacement a drill long enough to reach both femur and tibia from the trochanter is helpful.

The healing of a secondary arthrodesis is a slow process. Ten weeks of initial fixation is usually recommended before stability is tested (Stulberg 1982; Thornhill, Dalziel and Sledge 1982) but healing time has been reported to be four to five months even in uncomplicated cases (Hagemann *et al.* 1978; Brodersen *et al.* 1979; Woods *et al.* 1983). We chose a four-month initial period of fixation. If there is delay in fusion there should be no hesitation in grafting cancellous bone, or if a pseudarthrosis is developing in repeating the arthrodesis. Provided that an adequate method of fixation is used, the chance of success in our series was as good as the second attempt (4 out of 5) as at the first operation (14 out of 17).



Fig. 4



Fig. 5

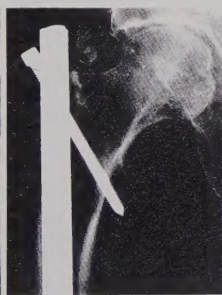


Fig. 6

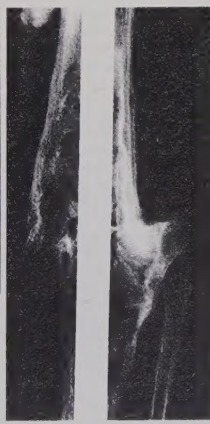


Fig. 7

Case 9. Figure 4—Lateral radiograph of an unstable fibrous fusion of the knee with a fractured intramedullary nail. Figure 5—A larger diameter nail was inserted but migrated proximally. Figure 6—The reinserted nail was locked with a screw. Figure 7—Anteroposterior radiograph to show bony healing at six months.

The treatment of infected failures by a two-stage procedure, using temporary gentamicin-containing beads, has been shown to be safe. It has also been clear that the initiation of systemic treatment with antibiotics, based on reliable cultures, before starting arthrodesis and bone transplantation has been beneficial. Stable fixation is important both to help control infection and to institute fusion (Hagemann *et al.* 1978; Vahvanen 1979). When starting a two-stage procedure we try to achieve good bone contact at the first operation so that it may be possible to achieve arthrodesis by external fixation or by a support should a second major operation be contra-indicated.

The choice between a revision arthroplasty and an arthrodesis must be influenced by many factors: the general health of the patient, the condition of adjacent joints, the state of the soft tissues around the knee, previous surgery, the type of failure of the primary arthroplasty, the virulence and sensitivity of any infective organisms and the needs of the patient in the activities of daily living (Thornhill *et al.* 1982).

One of the most important factors is the amount and quality of bone stock. We considered that arthrodesis was best when failure of the arthroplasty was due

to poor bone quality, to progressive insufficiency of ligaments or muscles, or to infection of a hinge prosthesis. Revision arthroplasty was considered primarily for mechanical failure, especially if this was due to technical error, and for infected compartmental arthroplasties. A revision arthroplasty or an arthrodesis should be performed early in the course of progressive failure in order to save bone stock. This is especially true of cases with long-stemmed prostheses.

All 19 cases in which arthrodesis was attempted fused. The main reasons for this success were repeated revisions for infection, careful attention to skin problems, cancellous bone grafting and the repetition of arthrodesis using stable types of fixation. Most patients, and especially those with rheumatoid arthritis involving the arms, suffer great disability from an unstable painful pseudarthrosis of the knee (Knutson *et al.* 1984b). The treatment of these patients is very demanding and should probably be concentrated at clinics which specialise in knee surgery and its complications.

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